

Structural characteristics of winter storms in southern Washington and northern Oregon

Sandra Yuter,
Catherine Spooner and Tim Downing
University of Washington
5 March 2005

Use of observations for model evaluation and diagnosis

- What structural characteristics of storms are most important to reproduce in numerical models?
- What subset of characteristics can we most reliably observe?
- How do we distinguish between details that are unique to an individual storm versus those that are repeated among a group of storms?

Routine Daily comparison of observations to forecast model output

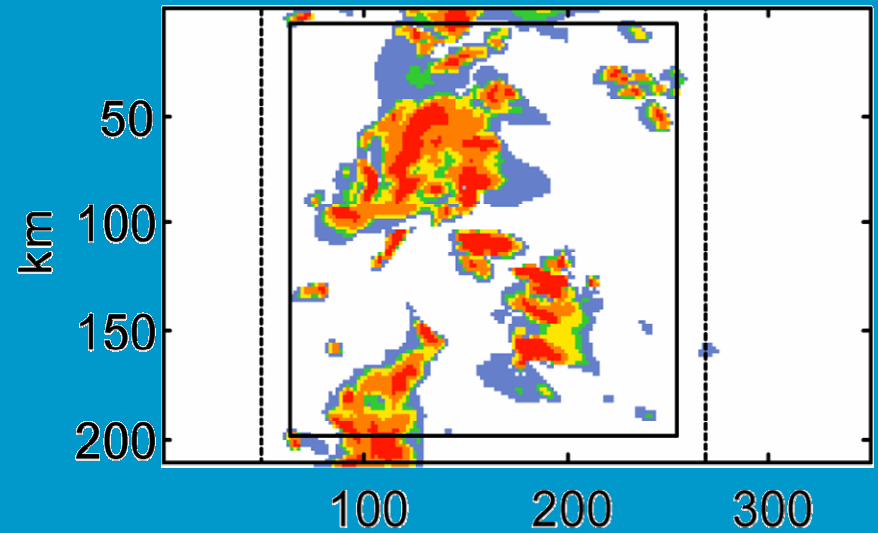
- Directly comparable products derived from observations and model output yield objective measures of:
 - Confidence in forecast model output for particular storm type
 - Model strengths and weaknesses
 - Evaluation of proposed model changes
 - Diagnosis of error sources

What should the
model/observations comparison
products look like?

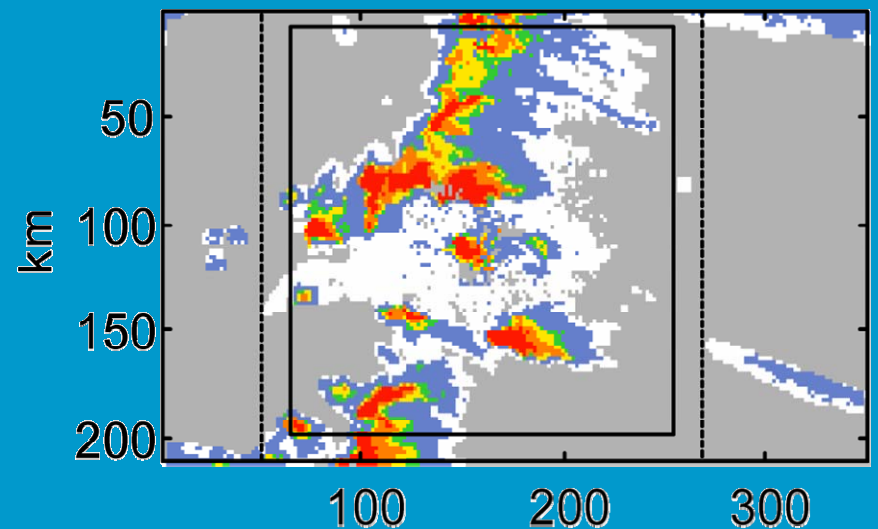
Model to Observation Comparison of Surface Rainfall

1 km cloud resolving
model with explicit
microphysics (ARPS) of
Ft. Worth Texas storm for
time=0
(Smedsmo et al, 2005)

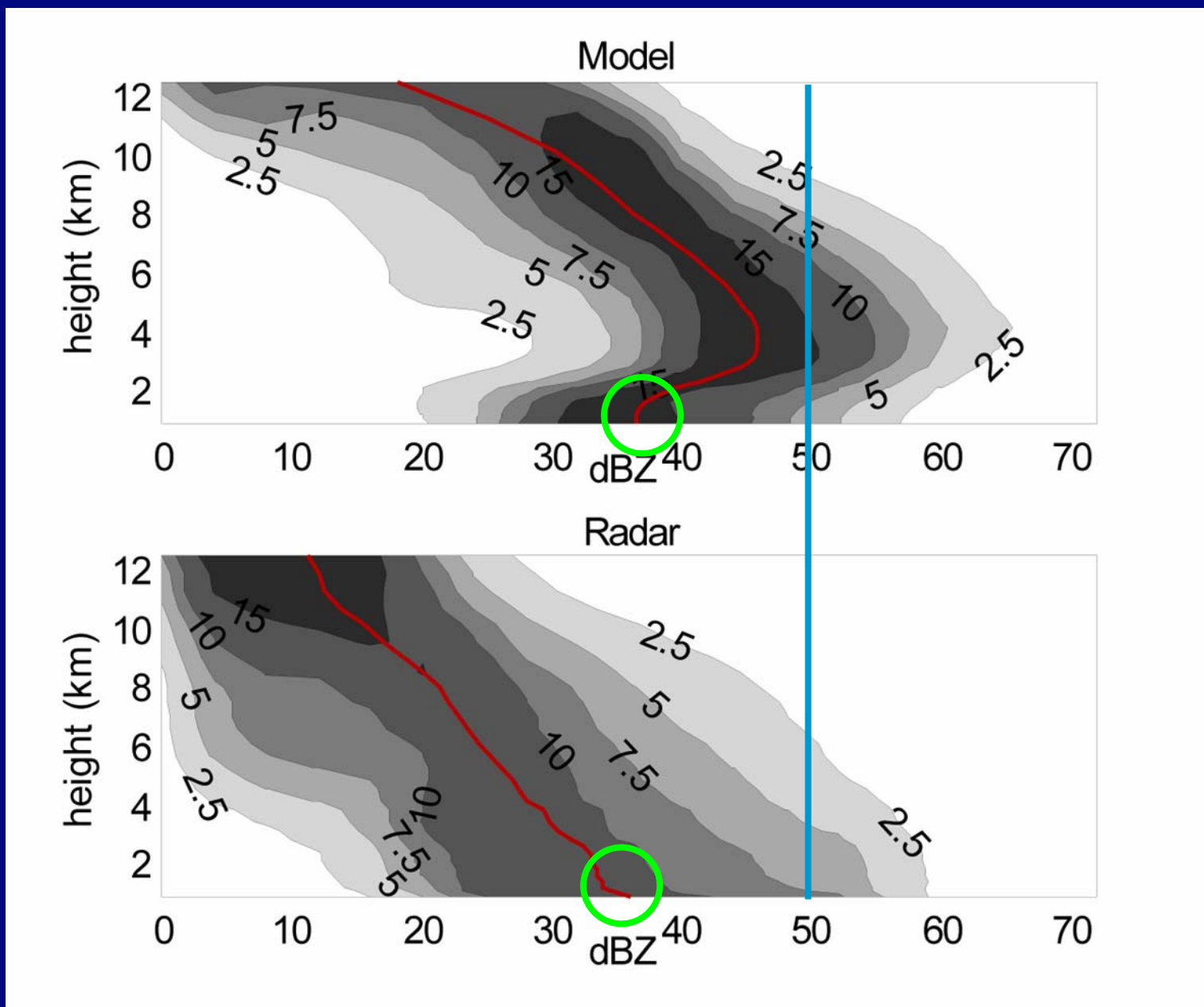
Model Rain Rate



Radar Rain Rate



Volumetric comparison for accumulated storm totals



Evaluation of Model Output must be 3D!

- Surface fields necessary but not sufficient for comparisons
- Operational WSR-88D radar can provide 3D precipitation structure and wind field information
- Supplemental vertically-pointing radar can provide fine-scale information on freezing level and sub-grid scale variability

METEK Inc. Radar in Scholls, OR

Ku-band
(1.25 cm wavelength)

Cost ~ \$16K

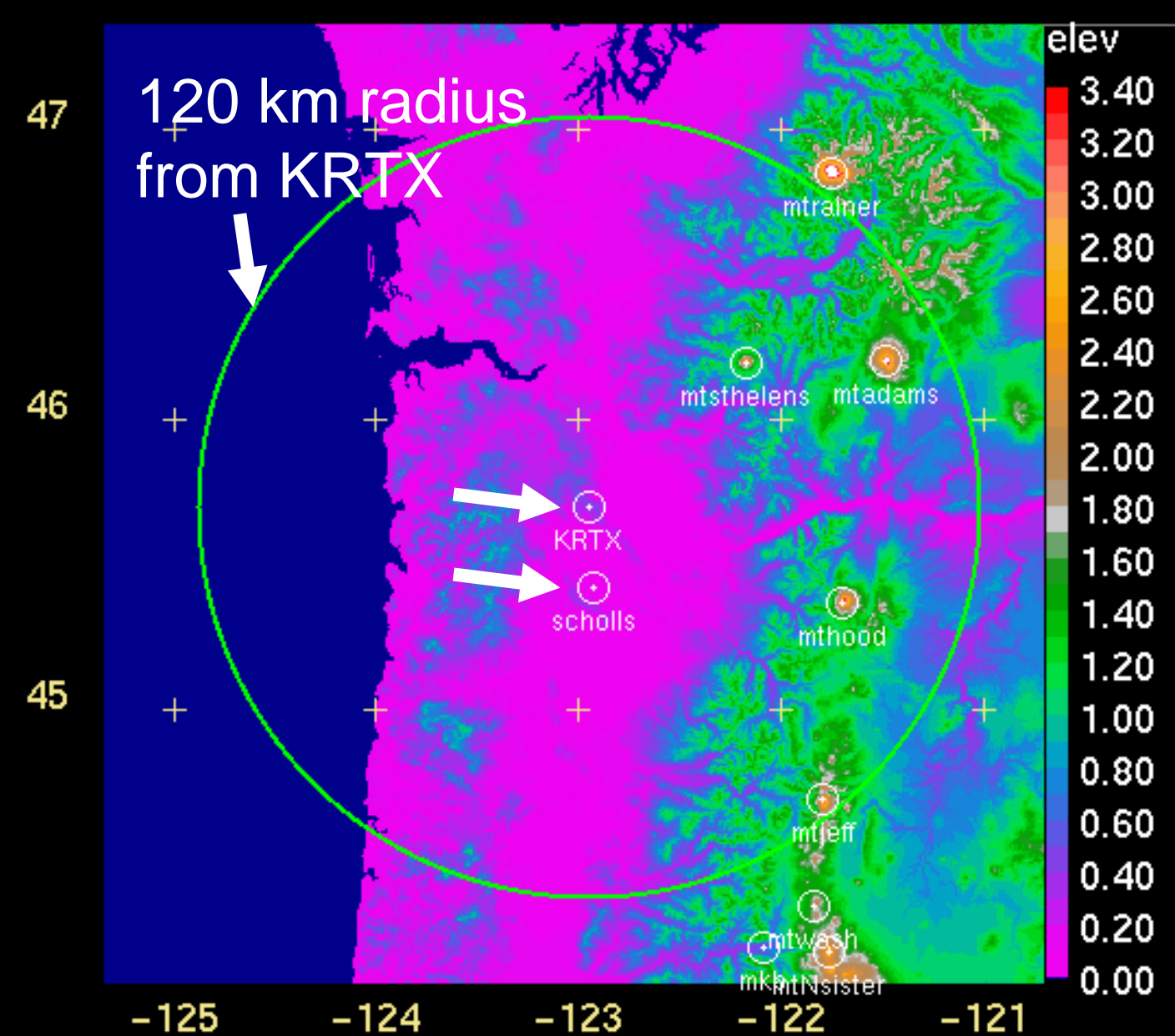
Resolution ≤ 150 m

Measurements of:

- Doppler velocity
- dBZ- attenuates in moderate to heavy rain

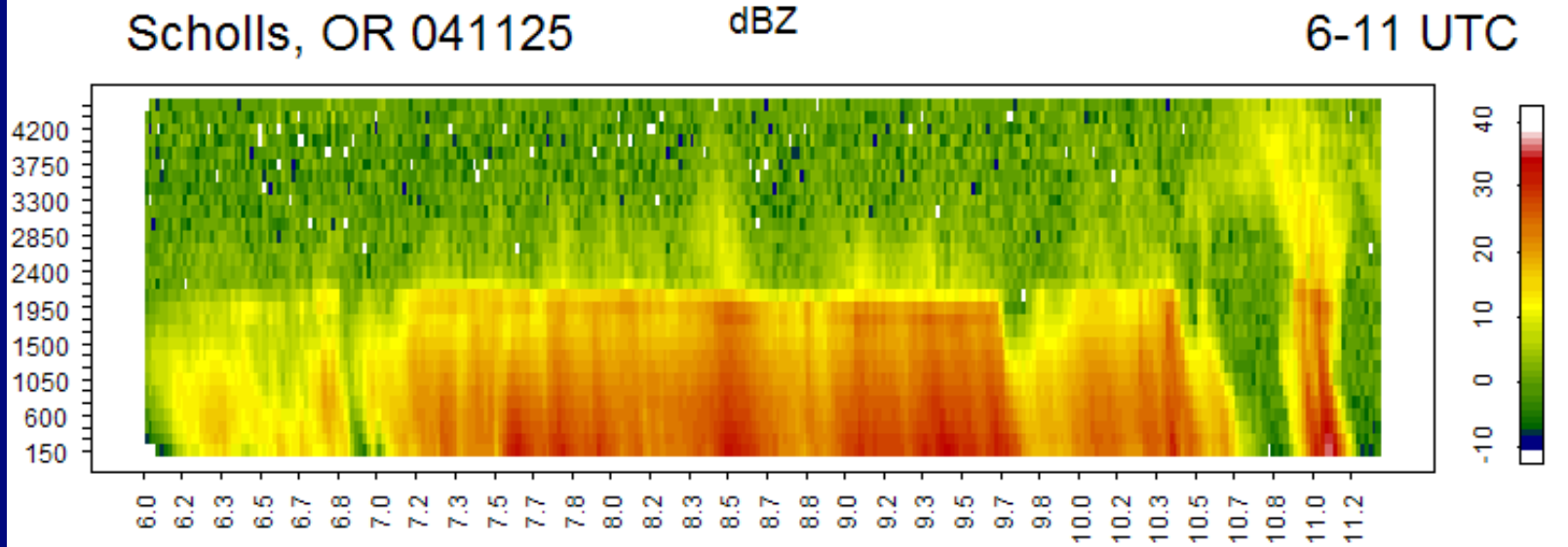


Prototype Concepts in Portland, Oregon Area



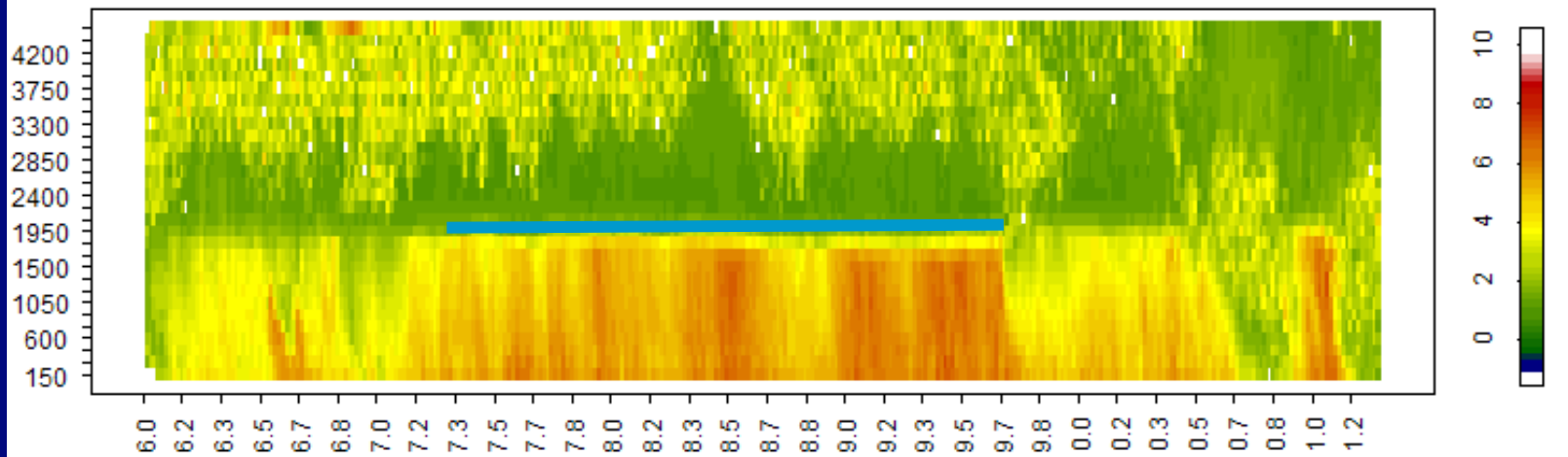
Variable freezing level

Height (m)



UTC Time (hours)

Doppler Velocity



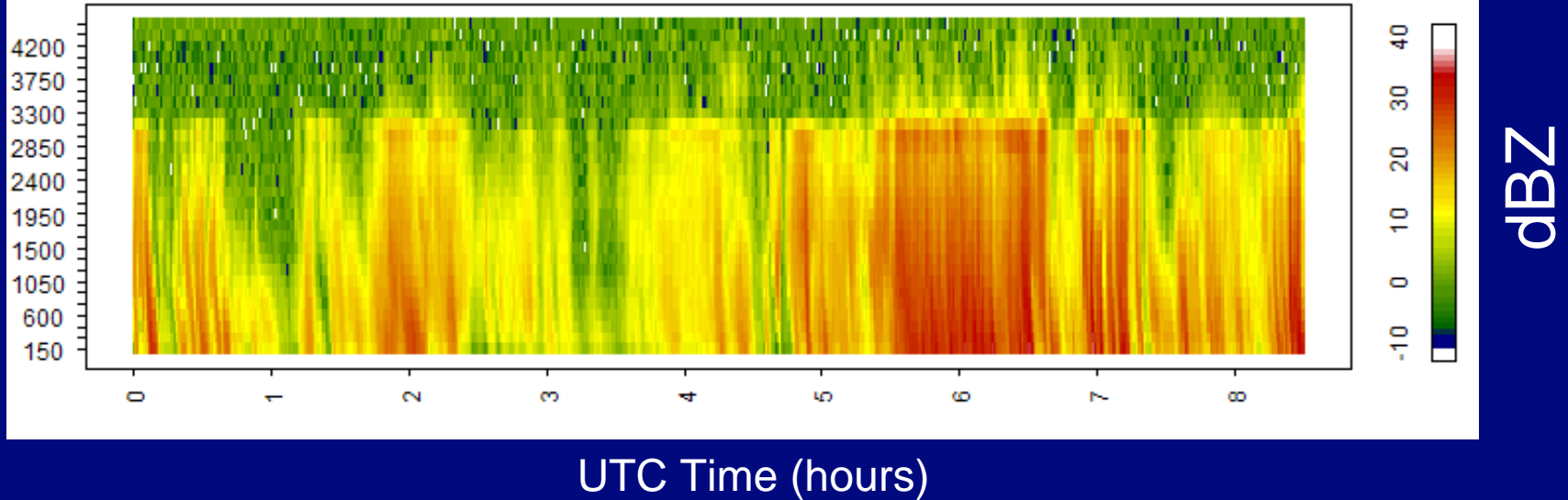
UTC Time (hours)

Variable freezing level

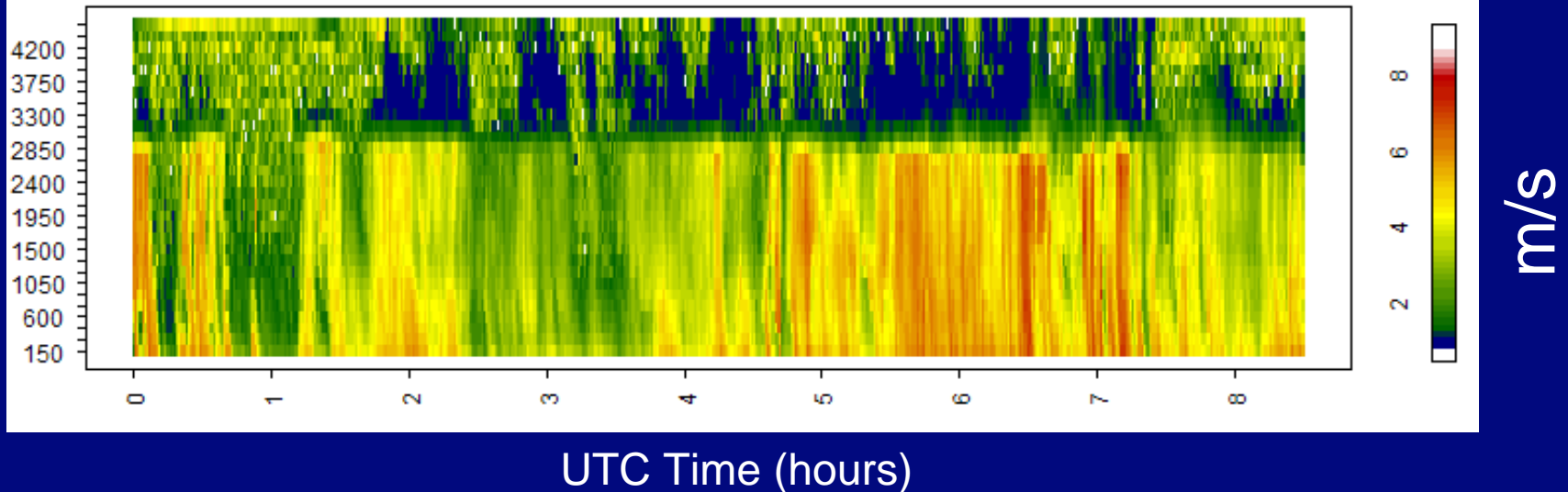
Scholls, OR 050118

dBZ

0-9 UTC



Doppler Velocity



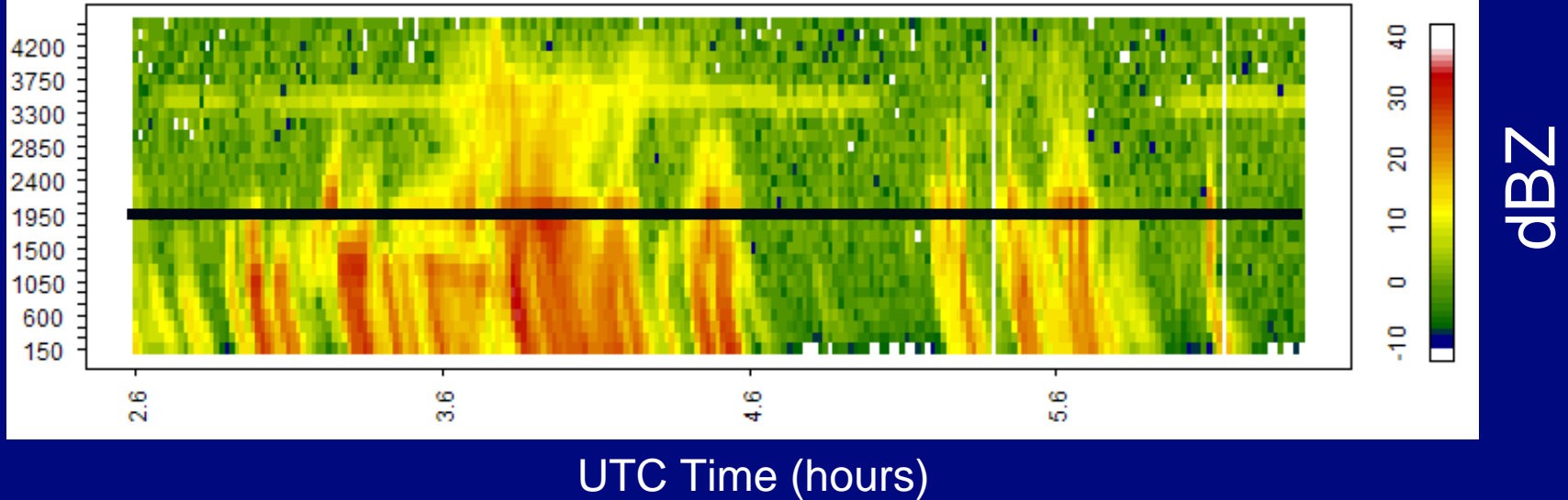
Variable freezing level

Height (m)

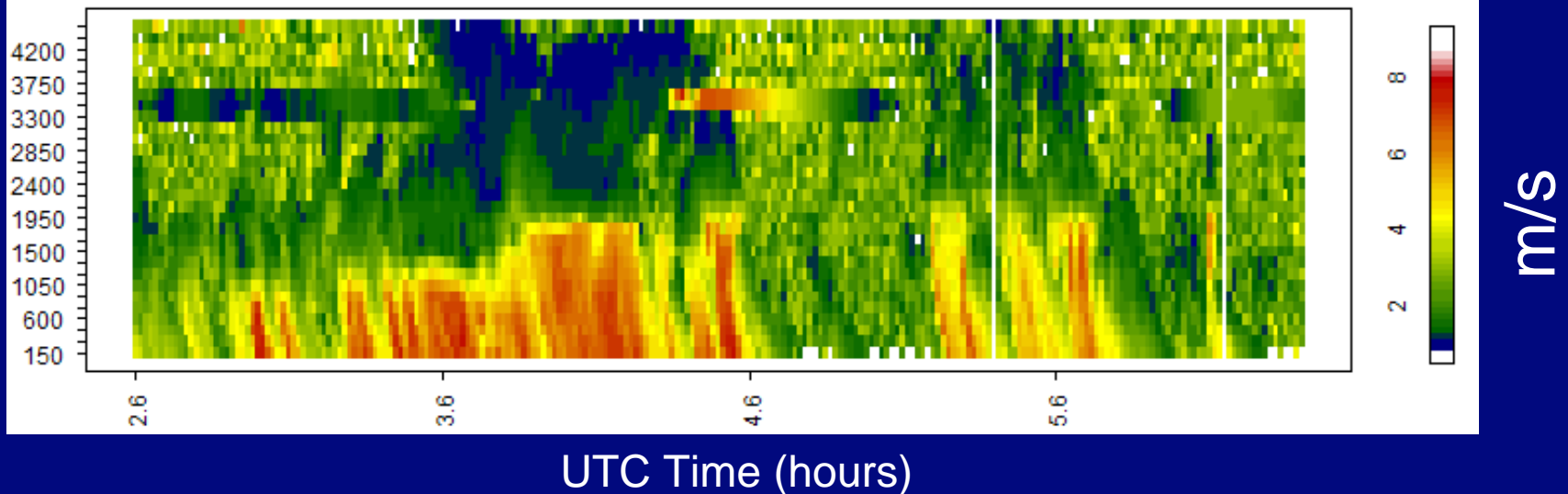
Scholls, OR 050116

dBZ

2.6 - 6.4 UTC



Doppler Velocity

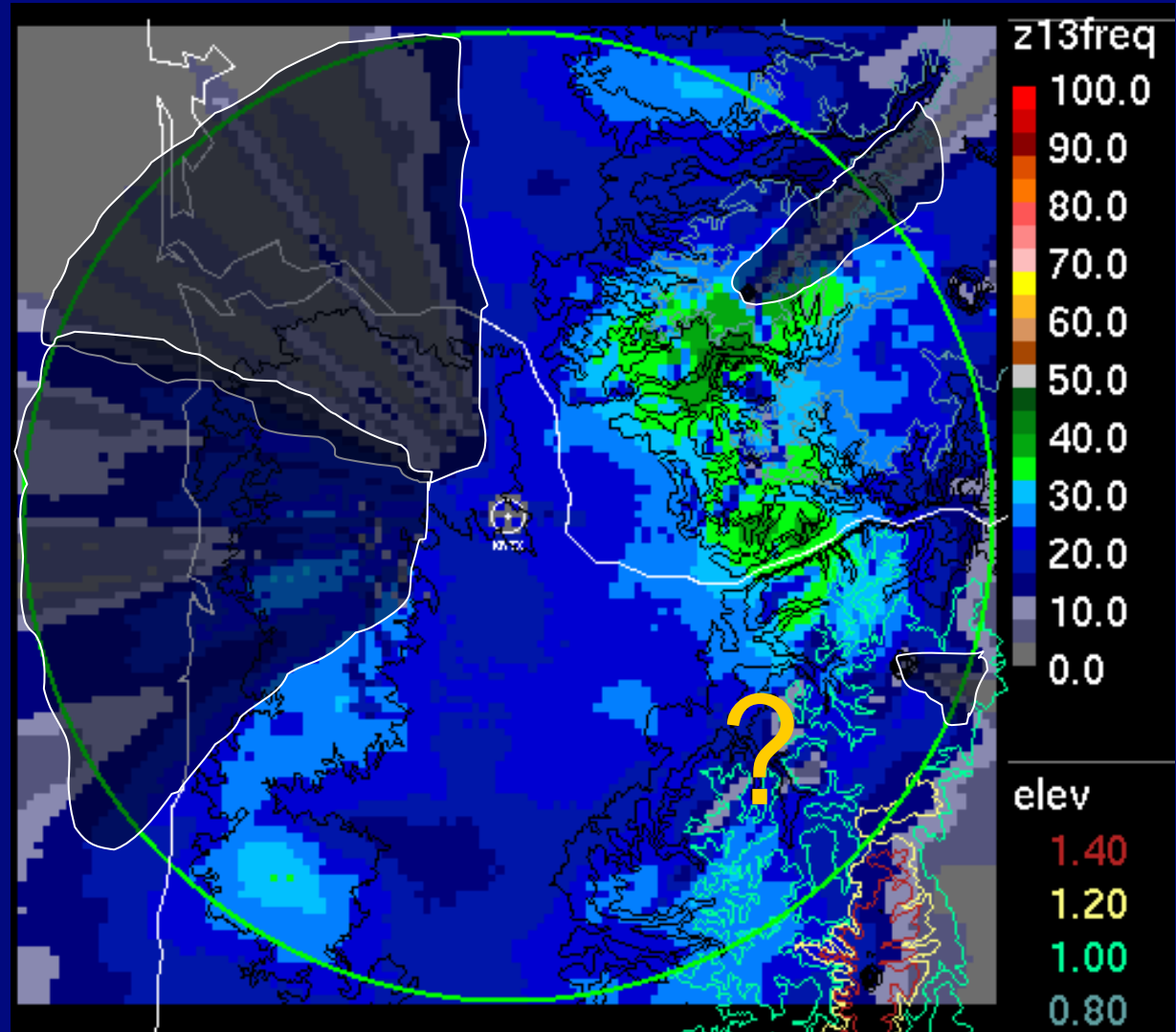


What sub area around radar can we use for comparisons?

Radar

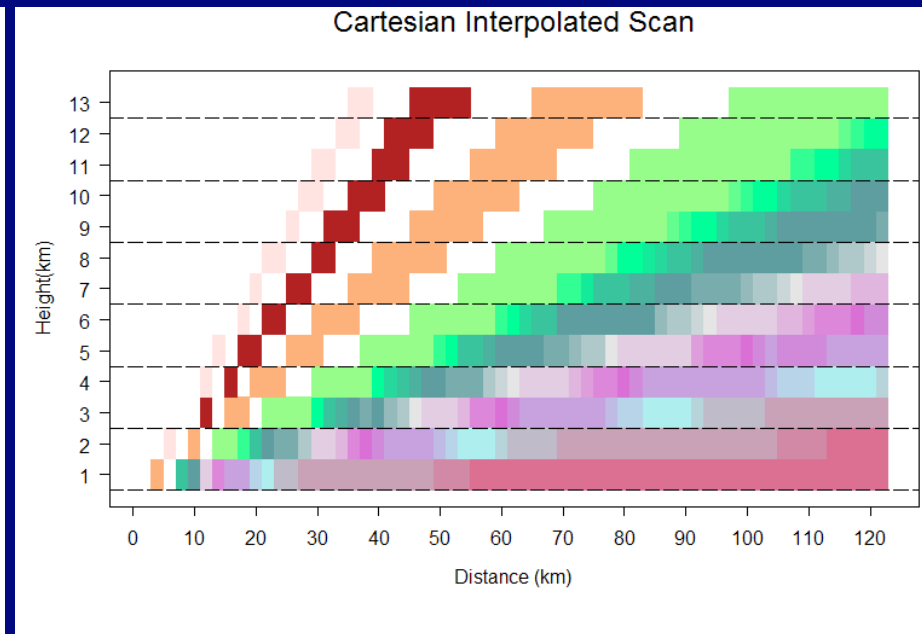
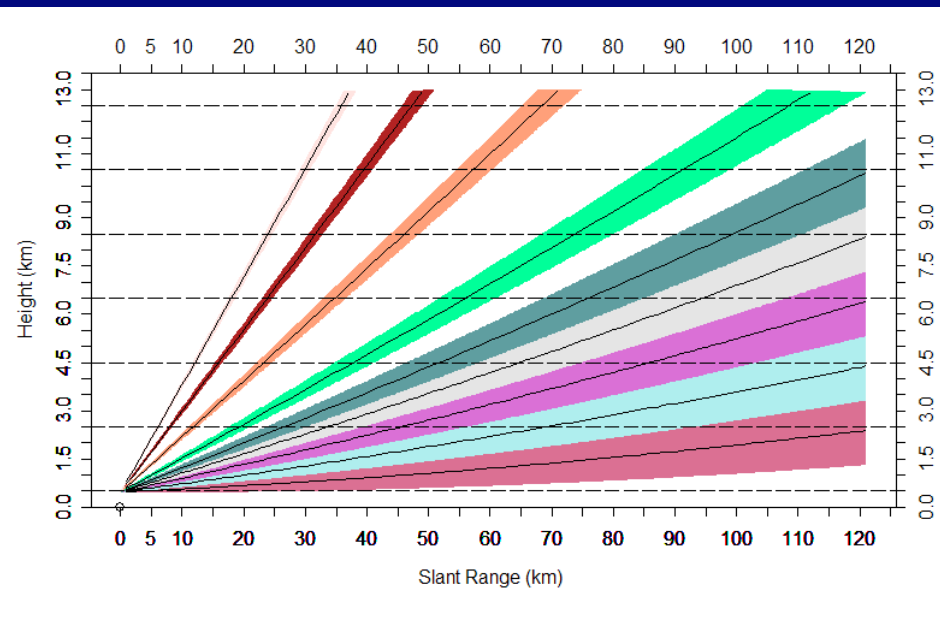
Visibility:

- Total
- Partial
- Blocked



Interpolate Polar Radar Data to Cartesian Coordinate System

WSR-88D Precip Scan



- Spatial coordinates similar to model
- Minimize range dependence of radar data

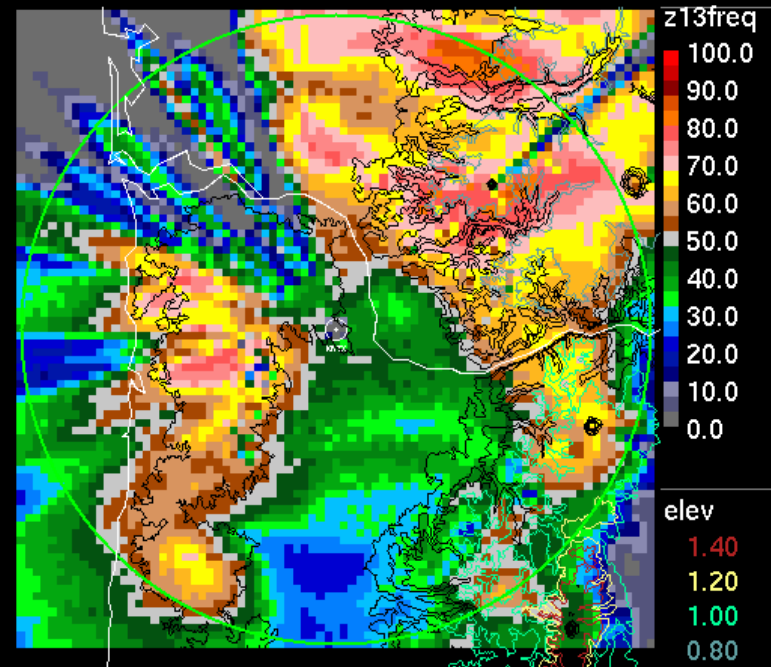
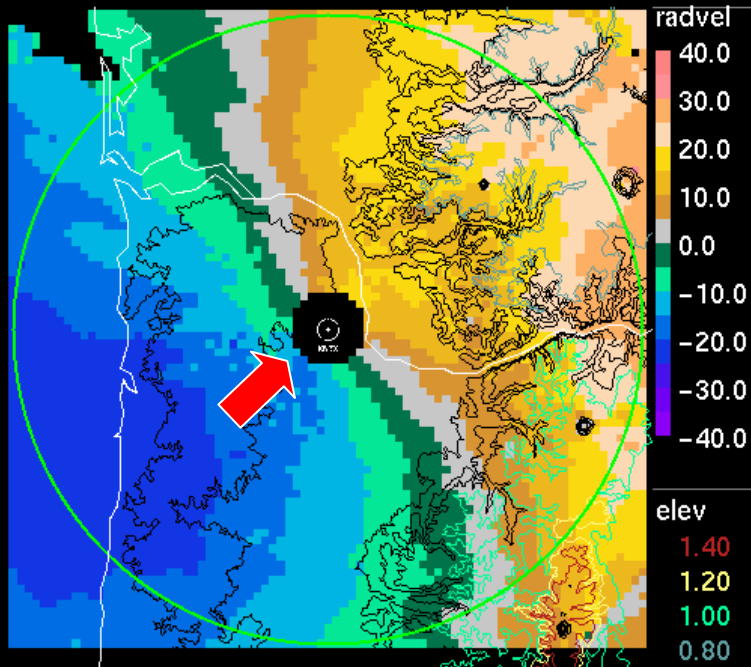
17 - 18 Jan 2005 storm

Wind Field (radial velocity)

Freq. of Echo ≥ 13 dBZ

17-jan-2005,04:20:00 Zebra projection: storm_aver_krtx_3d
radvel plot. Elev elev contour.

17-jan-2005,04:20:00 Zebra projection: storm_aver_krtx_3d
z13freq plot. Elev elev contour.



1.0 km altitude

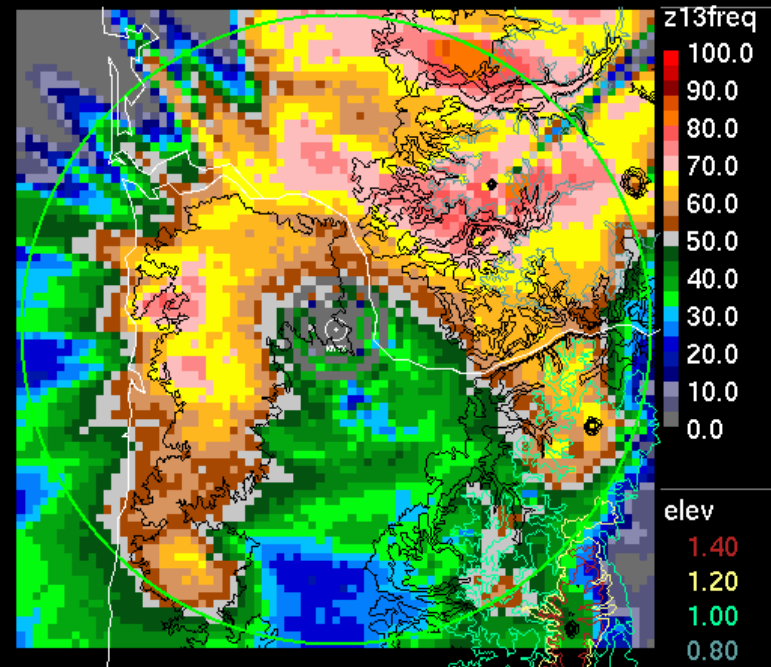
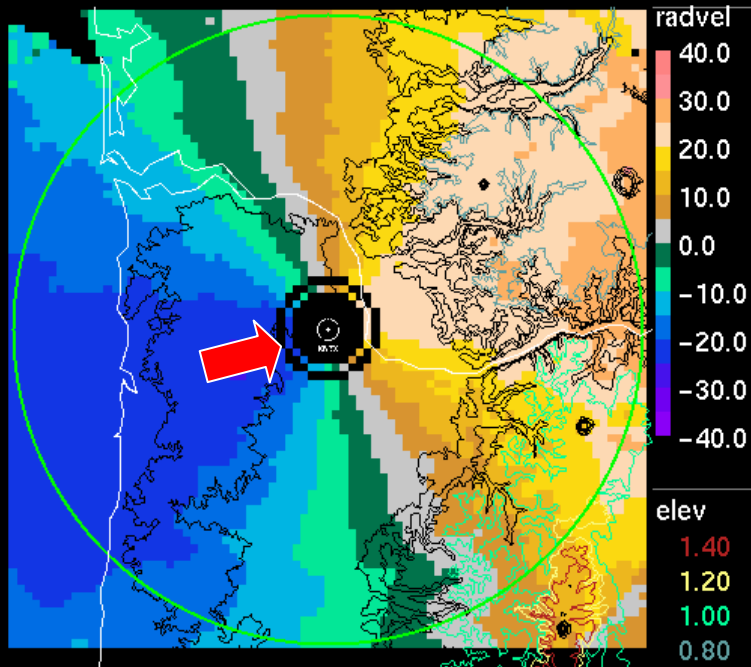
17 - 18 Jan 2005 storm

Wind Field (radial velocity)

Freq. of Echo ≥ 13 dBZ

17-jan-2005,04:20:00 Zebra projection: storm_aver_krtx_3d
radvel plot. Elev elev contour.

17-jan-2005,04:20:00 Zebra projection: storm_aver_krtx_3d
z13freq plot. Elev elev contour.



3.0 km altitude

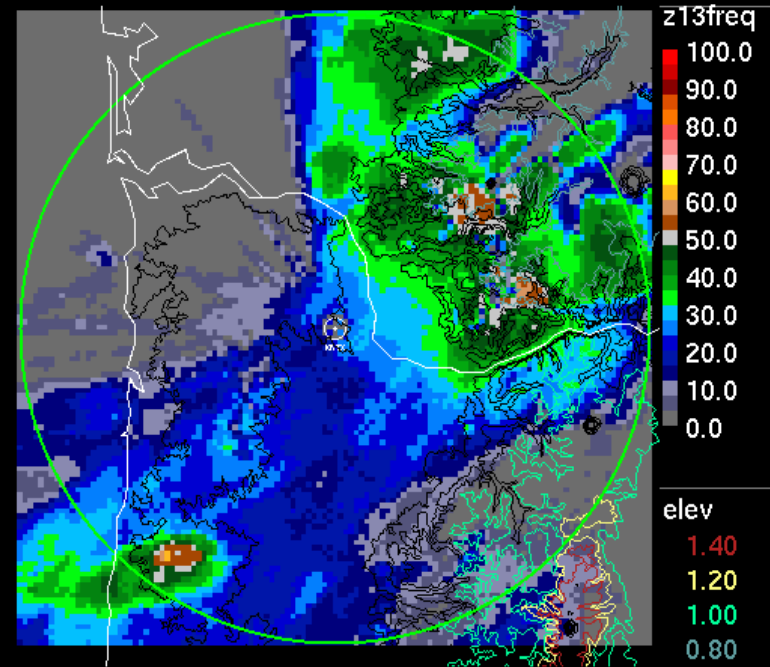
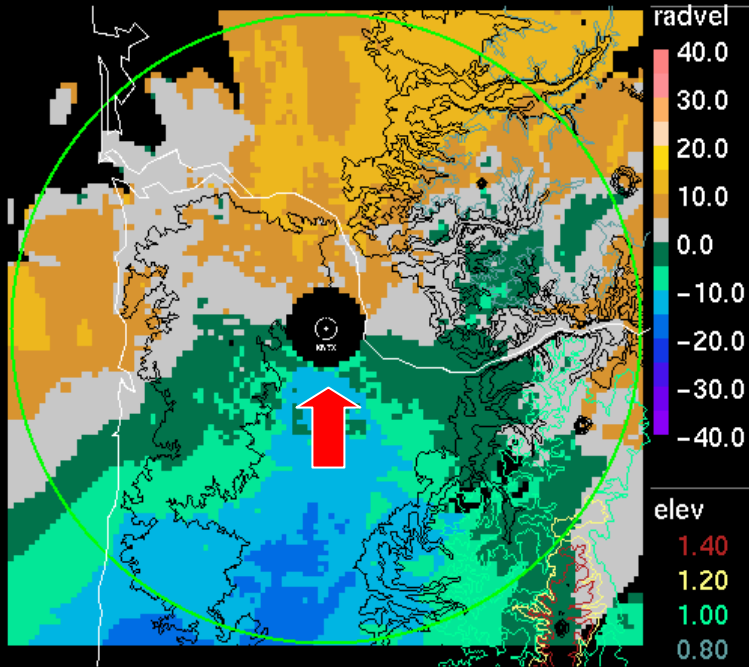
31 Dec - 1 Jan storm

Wind Field (radial velocity)

Freq. of Echo ≥ 13 dBZ

31-dec-2004,15:47:00 Zebra projection: storm_aver_krtx_3d
radvel plot. Elev elev contour.

31-dec-2004,15:47:00 Zebra projection: storm_aver_krtx_3d
z13freq plot. Elev elev contour.



1.0 km altitude

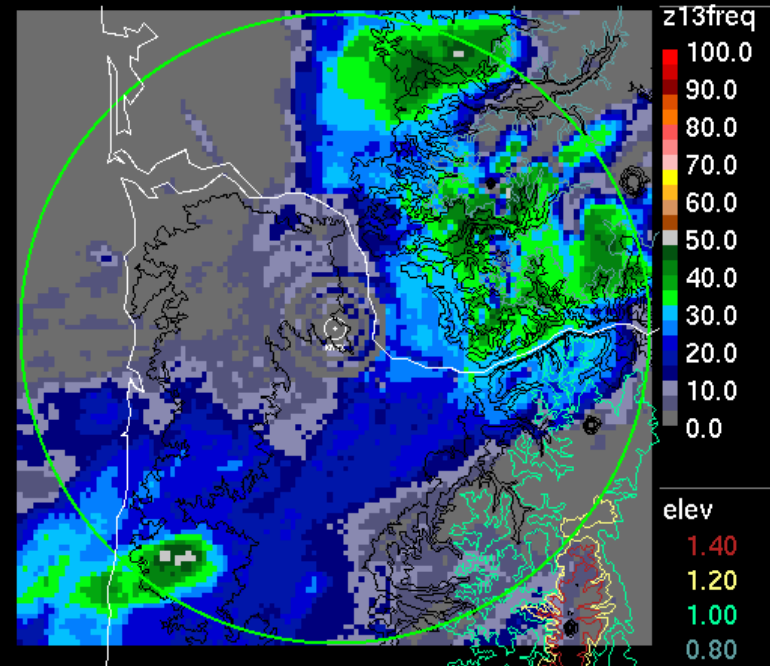
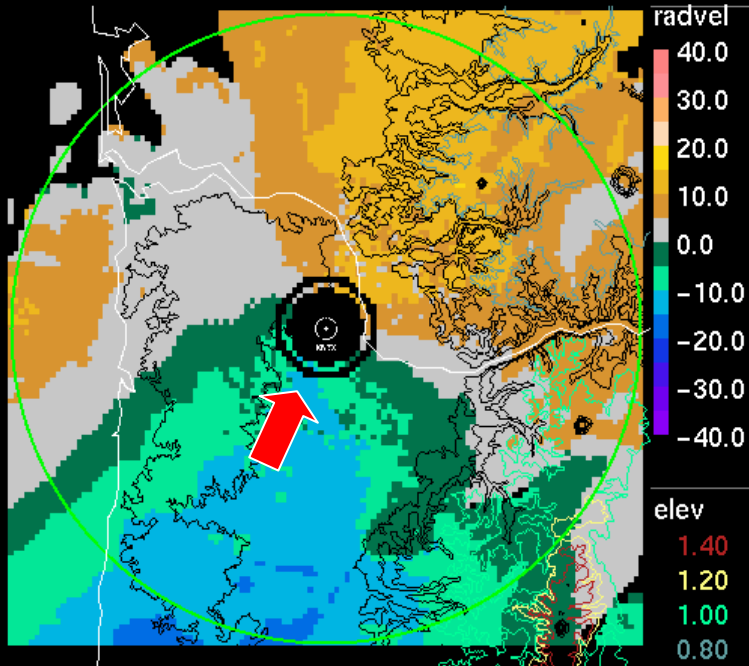
31 Dec - 1 Jan storm

Wind Field (radial velocity)

Freq. of Echo ≥ 13 dBZ

31-dec-2004,15:47:00 Zebra projection: storm_aver_krtx_3d
radvel plot. Elev elev contour.

31-dec-2004,15:47:00 Zebra projection: storm_aver_krtx_3d
z13freq plot. Elev elev contour.



3.0 km altitude

Conclusions

- Orography limits radar's visibility, compare with model over subarea of domain
- Interpolate radar data to Cartesian grid
 - minimize range dependence
 - common coordinate system with model
- Variable freezing level height in winter complicates use of quantitative dBZ statistics

Suggested Observed 3D Characteristics for Forecasts of Winter Storms to Reproduce

From WSR-88D:

- Wind field pattern (radial velocity)
- Precipitation frequency pattern

From vertically-pointing radar

- Freezing level altitude (location, time)

The End

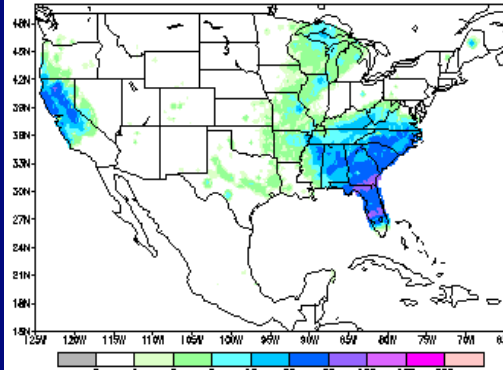
International Precipitation Working Group

Sample of Daily Precip Comparison Product for CONUS

Web-accessible

13Z 27Feb2005 thru 12Z 28Feb2005
Data on 0.25 deg grid (UNITS are mm/day)

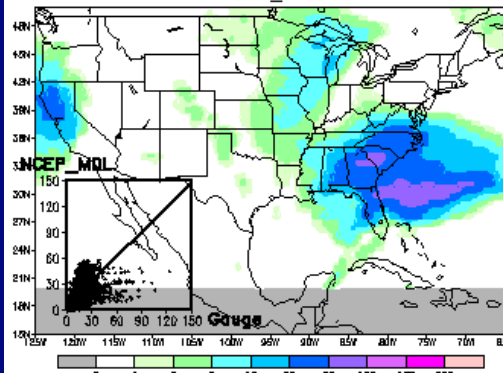
CPC real-time Gauge Analysis



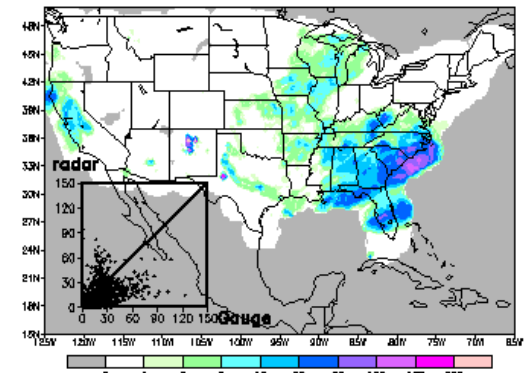
| | (G) gauge | (S) NCEP_MDL | (R) radar |
|----------------------------|--------------|-----------------|--------------|
| Number of points: | 10799. | 10799. | 10799. |
| # points w/rain: | 3857. | 4834. | 3552. |
| Mean rain rate: | 3.99 | 4.78 | 2.86 |
| Cond. rain rate: | 11.14 | 10.51 | 8.53 |
| Max. rain rate: | 123.29 | 56.89 | 345.81 |
| | | | |
| Correlation: | G-S | G-R | R-S |
| Mean Absolute Error: | 0.767 | 0.543 | 0.516 |
| RMSE (mm/day): | 2.66 | 3.27 | 3.27 |
| RMSE (normalized): | 6.53 | 6.48 | 9.31 |
| Probability of Detection: | 1.64 | 2.13 | 3.24 |
| False Alarm Ratio: | 0.897 | 0.802 | 0.904 |
| Bias Ratio (rain:no rain): | 0.284 | 0.129 | 0.336 |
| Haidke Skill Score: | 1.253 | 0.921 | 1.361 |
| Hanssen-Kuipers Score: | 0.662 | 0.750 | 0.623 |
| Hanssen-Kuipers Score: | 0.699 | 0.737 | 0.680 |
| Equitable Threat Score: | 0.494 | 0.600 | 0.453 |

| | NCEP_MDL | | radar | |
|-----------|----------|-------|-------|-------|
| | < 1 | ≥ 1 | < 1 | ≥ 1 |
| gauge < 1 | 5567. | 1375. | 6485. | 457. |
| gauge ≥ 1 | 308. | 3459. | 762. | 3095. |

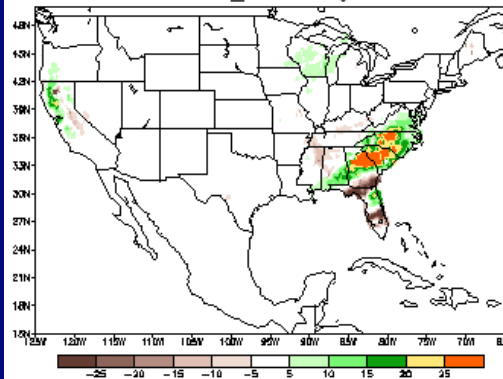
NCEP_MDL



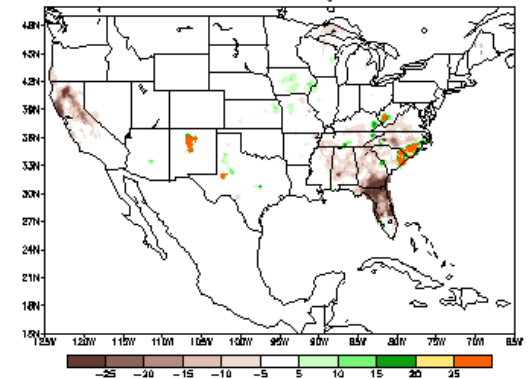
Radars



NCEP_MDL-Gauge

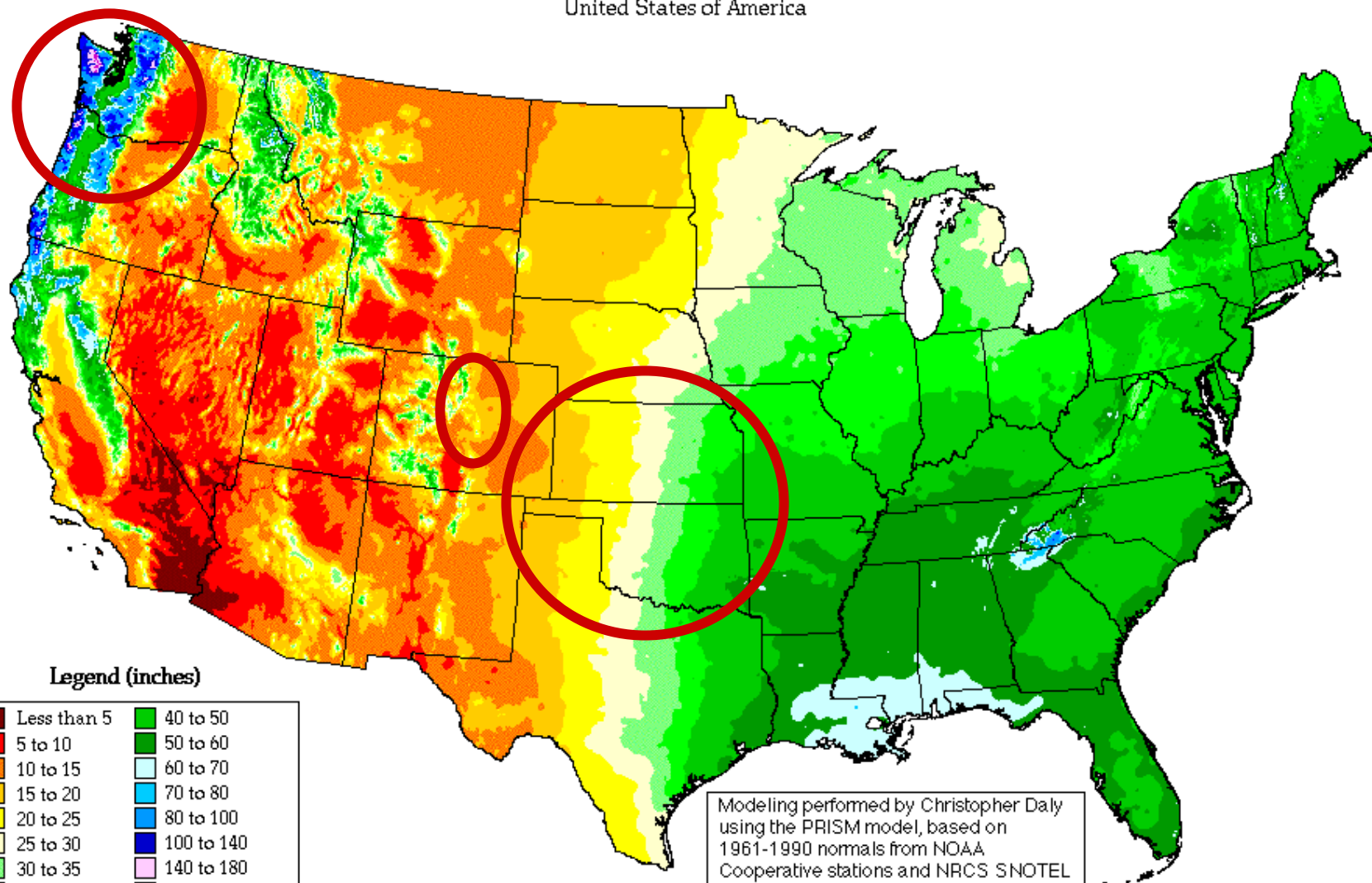


Radars-Gauge



Annual Average Precipitation

United States of America



Legend (inches)

| | |
|-------------|---------------|
| Less than 5 | 40 to 50 |
| 5 to 10 | 50 to 60 |
| 10 to 15 | 60 to 70 |
| 15 to 20 | 70 to 80 |
| 20 to 25 | 80 to 100 |
| 25 to 30 | 100 to 140 |
| 30 to 35 | 140 to 180 |
| 35 to 40 | More than 180 |

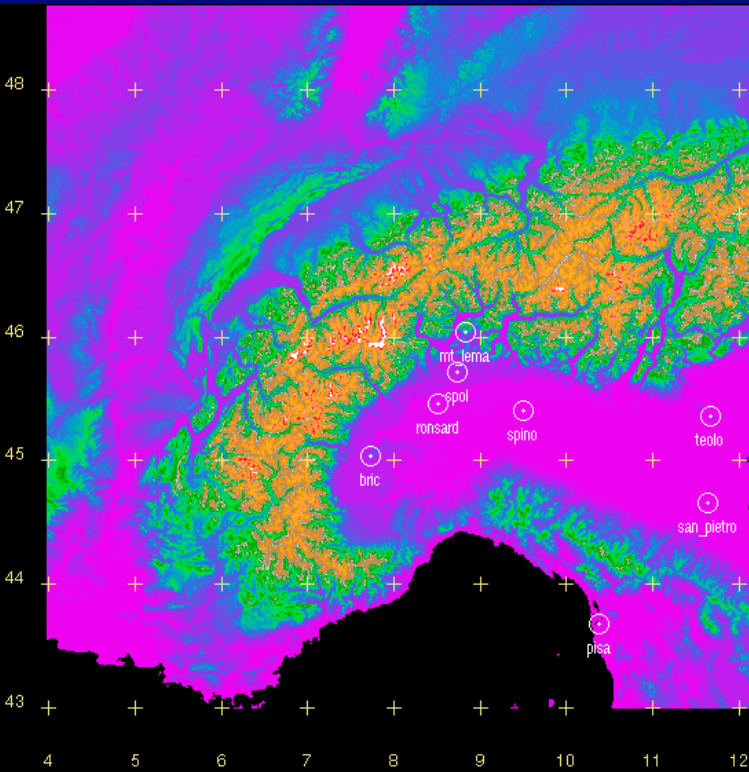
Period: 1961-1990

Copyright 2000 by Spatial Climate Analysis Service, Oregon State University

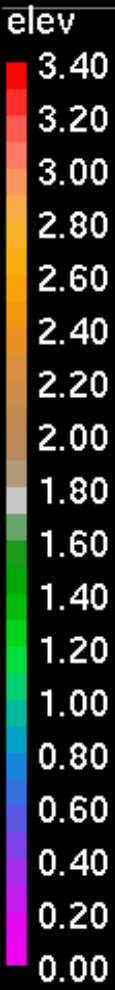
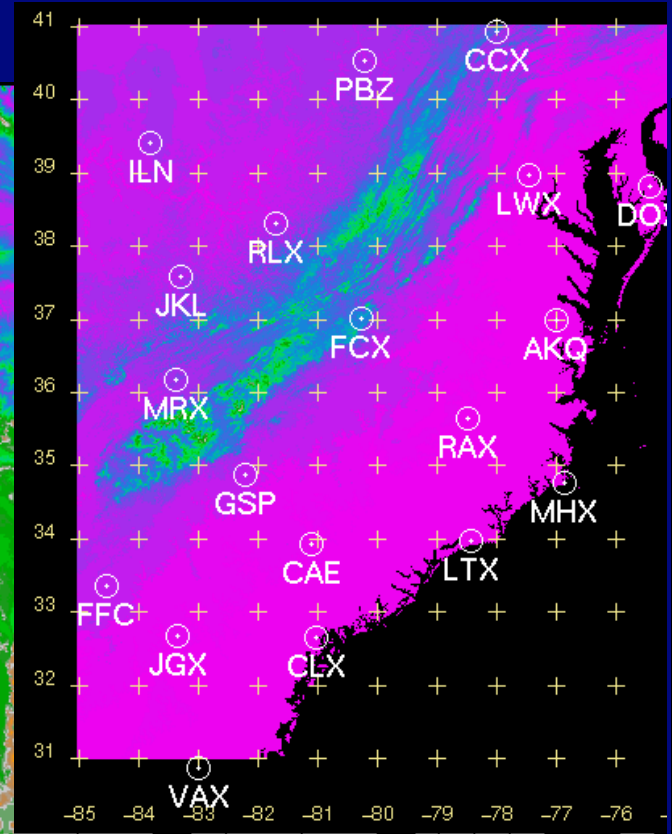
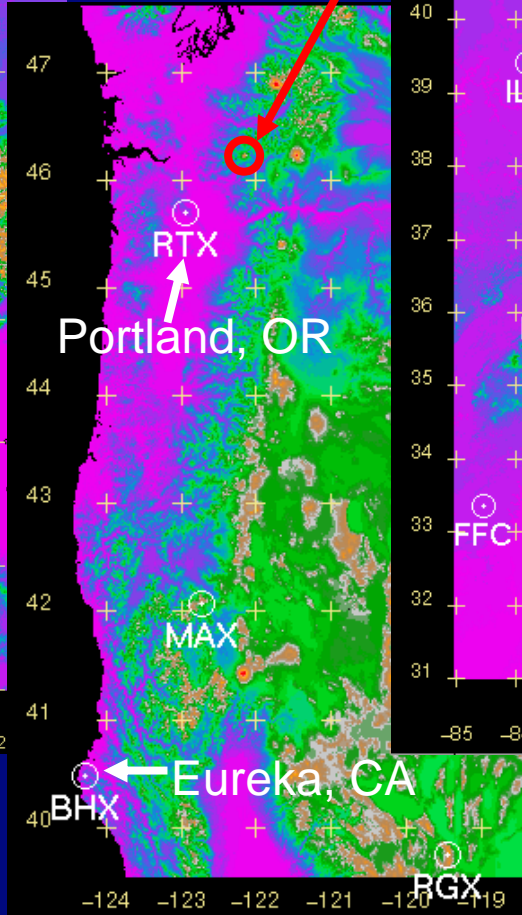
Modeling performed by Christopher Daly using the PRISM model, based on 1961-1990 normals from NOAA Cooperative stations and NRCS SNOTEL sites. Sponsored by USDA-NRCS Water and Climate Center, Portland, Oregon.

Oregon Climate Service
George Taylor, State Climatologist
(541) 737-5705

Alps



Mt. St. Helens



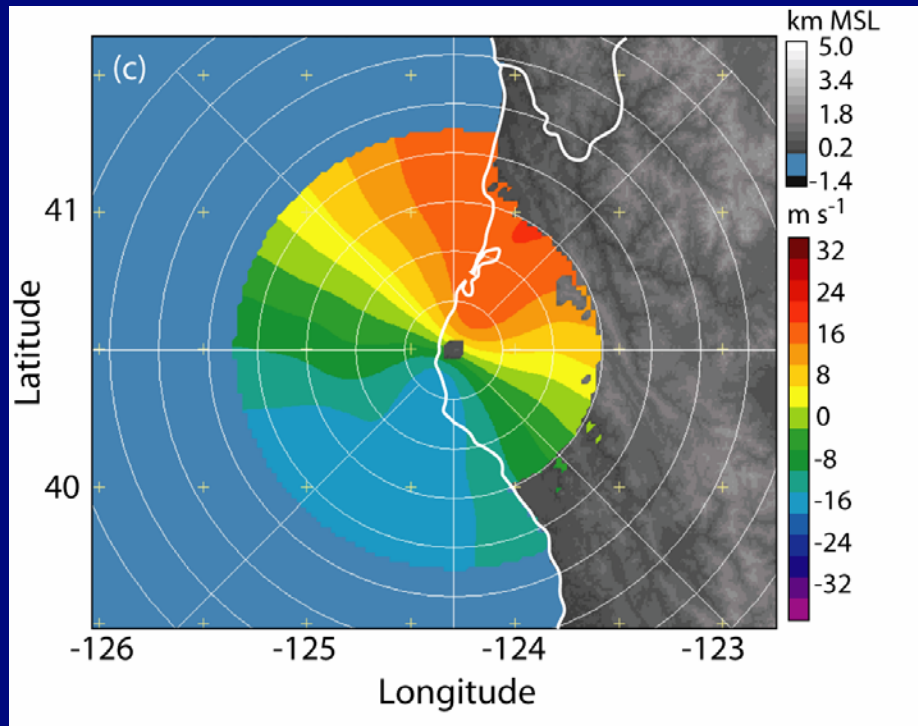
Topography Comparison

Central W Coast

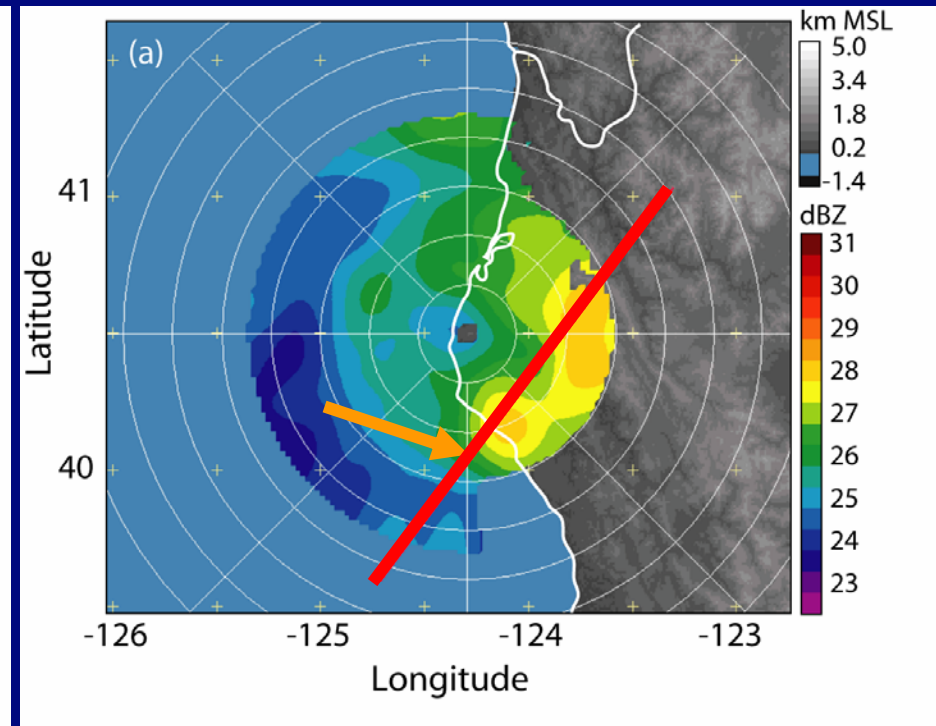
Carolinas

Mean Patterns for 61 Rain Events

Eureka, CA WSR-88D radar Oct 1995 – March 1998

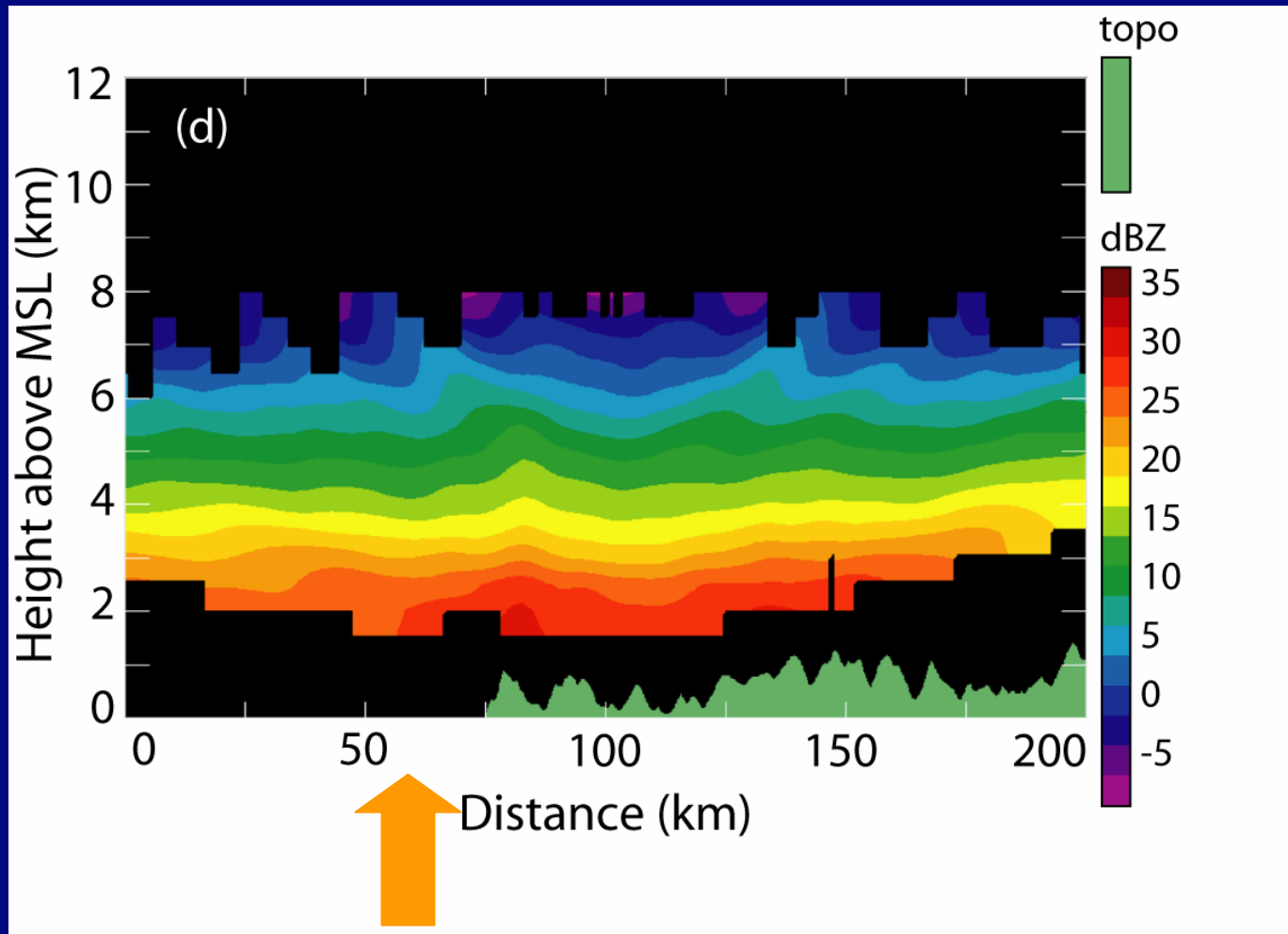


Mean Radial Velocity



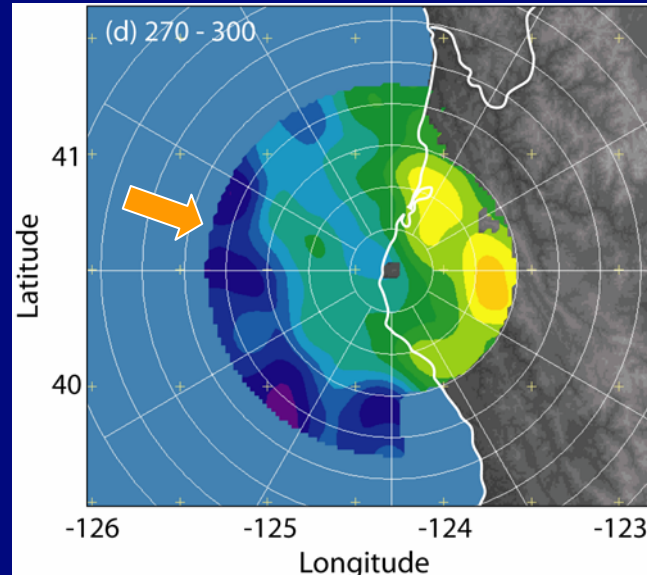
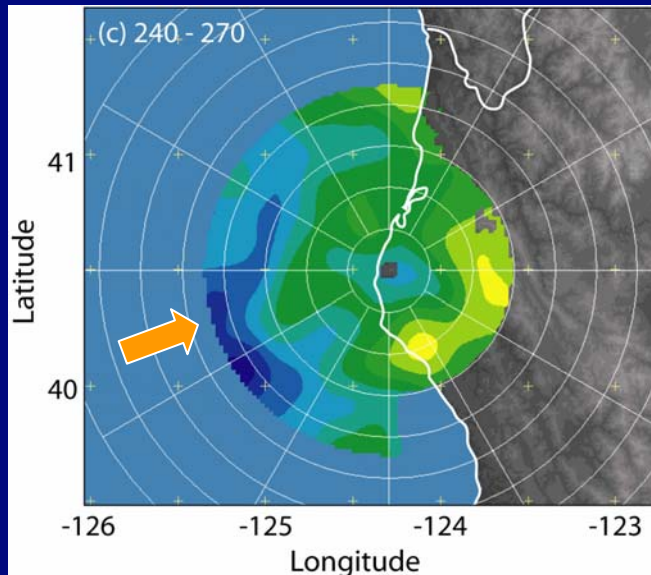
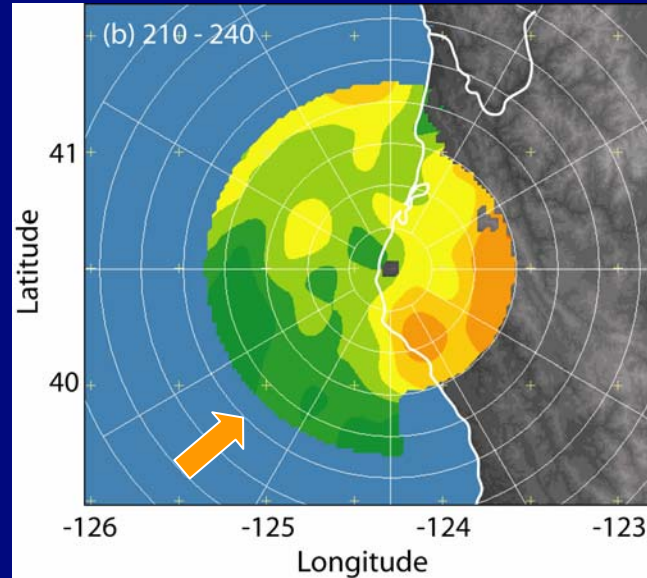
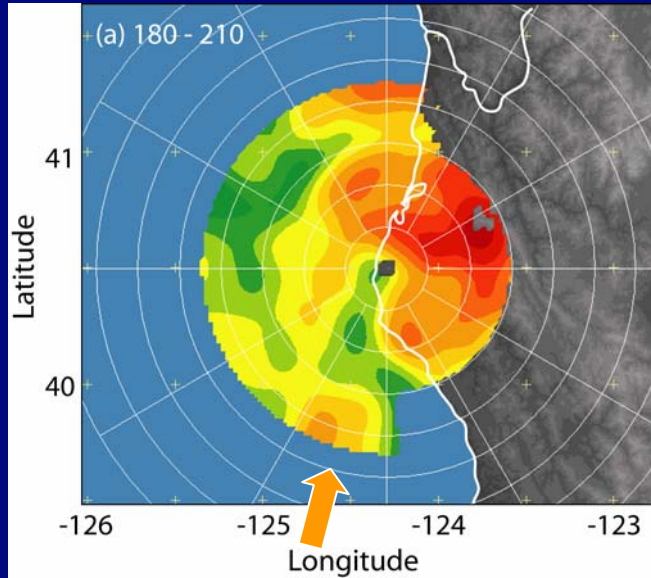
Conditional Mean Reflectivity

Mean Reflectivity Cross-Section

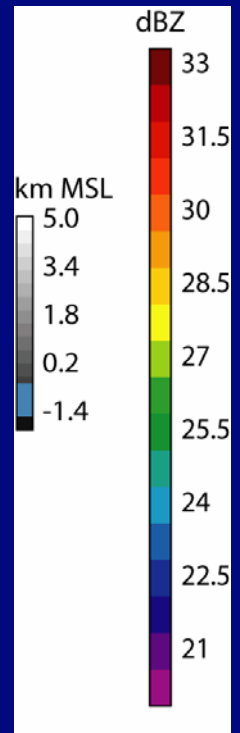


Enhancement of precipitation over ocean upwind of coastal mountains (James, 2004)

Different reflectivity patterns for different wind directions



Mean Z
2 km
altitude



Radar-derived precipitation products

- Existence, Precip.Area--Min. detectable surface precip rate
- Classification of precip structure in vertical and horizontal into rain, snow, mixed, graupel/hail
- Spatial pattern of precip. intensity
- Quantitative estimate of precip. intensity



Uncertainty